Claims

[c1] What is claimed is:

1.A method for reducing a blocking artifact in a video stream, the method comprising:
determining a filtering range according to block coding types of a plurality of adjacent blocks in the video stream, wherein the filtering range specifies a number of pixels to filter around a block boundary between the adjacent blocks; and
filtering a plurality of pixels around the block boundary according to the filtering range to reduce the blocking artifact in the video stream.

[c2] 2.The method of claim 1, further comprising determining a region mode according to local activity around the block boundary, wherein the plurality of pixels around the block boundary are filtered also according to the region mode.

[c3] 3.The method of claim 1, wherein according to the block coding types of the adjacent blocks in the video stream, the filtering range is determined to be up to eight pixels around the block boundary.

[c4] 4.The method of claim 1, wherein determining the filtering range according to the block coding types of the adjacent blocks in the video stream further comprises:
if at least one of the adjacent blocks is an intra-coded block, determining the filtering range to be up to four pixels around the block boundary; and
if none of the adjacent blocks are intra-coded blocks, determining the filtering range to be up to eight pixels around the block boundary.

[c5] 5.The method of claim 1, wherein determining the region mode according to the local activity around the block boundary between the adjacent blocks in the video stream further comprises:
calculating an activity value representing local activity around the block boundary; and
determining the region mode according to the activity value.

[c6] 6.The method of claim 4, further comprising calculating the activity value as a sum of absolute differences between pixels V_I around the block boundary as follows:

$$ACTIVITY = \sum_{i=4}^{6} |v_i - v_{i+1}| + \sum_{i=8}^{10} |v_i - v_{i+1}|$$

[c7] 7.The method of claim 4, wherein:
if at least one of the adjacent blocks is an intra-coded block:
if the activity value is greater than a first threshold, determining the region mode to be an active region;
if the activity value is less than the first threshold but greater than a second threshold, determining the region mode to be a smooth region; and
if the activity value is less than the second threshold, determining the region mode to be a dormant region; and
if none of the adjacent blocks are intra-coded blocks:
if the activity value is greater than a third threshold, determining the region mode to be an active region;
if the activity value is less than the third threshold but greater than the second threshold, determining the region mode to be a smooth region; and
if the activity value is less than the second threshold, determining the region mode to be a dormant region.

[c8] 8.The method of claim 7, wherein the second threshold is fixed at a predetermined value.

[c9] 9.The method of claim 8, wherein the predetermined value is 6.

[c10] 10.The method of claim 7, further comprising:
if at least one of the adjacent blocks is an intra-coded

block:
if the region mode is active region,
if a high frequency component c_3 is less than a fourth threshold, filtering the pixels around the block boundary according to the filtering range using a first filter;
if the region mode is smooth region,
if the absolute value of the difference of the pixel values on either side of the block boundary is less than a fifth threshold, filtering the pixels around the block boundary according to the filtering range using a second filter; and
if the region mode is dormant region,
if the absolute value of the difference of the pixel values on either side of the block boundary is less than the fifth threshold, filtering the pixels around the block boundary according to the filtering range using a third filter; and
if none of the adjacent blocks are intra-coded blocks:
if the region mode is active region,
if the high frequency component c_3 is less than a sixth threshold, filtering the pixels around the block boundary according to the filtering range using the first filter;
if the region mode is smooth region,
if the absolute value of the difference of the pixel values on either side of the block boundary is less than a seventh threshold, filtering the pixels around the block boundary according to the filtering range using the second filter; and

if the region mode is dormant region,
if the absolute value of the difference of the pixel values on either side of the block boundary is less than a seventh threshold, filtering the pixels around the block boundary according to the filtering range using the third filter.

[c11] 11.The method of claim 10, further comprising adaptively determining the first, third, fourth, fifth, sixth, and seventh thresholds by at least taking into account differences in quantization parameters QPs of the adjacent blocks.

[c12] 12.The method of claim 11, further taking into account a user defined offset (UDO) allowing the first, third, fourth, and fifth threshold levels to be adjusted according to the UDO value.

[c13] 13.The method of claim 10, wherein the high frequency component c_3 is calculated using pixels v_6, v_7, v_8, v_9 around the block boundary as follows:
$c_3 = (v_6 - v_7 + v_8 - v_9)/2$.

[c14] 14. The method of claim 10, wherein the first filter is a one dimensional filter formed by using a 4-point Hadamard Transform (HT), wherein the high frequency coefficient of the HT is reduced to 0 for frame-coded

pictures.

[c15] 15. The method of claim 10, wherein the first filter is a one dimensional filter formed by using a 4-point Hadamard Transform (HT), wherein the high frequency coefficient of the HT is reduced to one half for field-coded pictures.

[c16] 16.The method of claim 10, wherein the filtered pixels are further refined by adjusting a pixel quantized with a larger QP to have more change in value than a pixel quantized with a smaller QP.

[c17] 17.The method of claim 16, wherein a first weighting value WT1 and a second weighting value WT2 are used for adjusting the filtered pixels and are obtained from a first quantization parameter QP1 of a first adjacent block and a second quantization parameter QP2 of a second adjacent block as follows:

$$WT1 = {}^{QP1}\!\big/_{QP1+QP2}\ ,\quad WT2 = {}^{QP2}\!\big/_{QP1+QP2}$$

[c18] 18.The method of claim 10, wherein if quantization parameters (QPs) of the adjacent blocks are the same, symmetric second and third filters are used to filter the pixels around the block boundary for smooth and dormant region modes, respectively; and

if the QPs of the adjacent blocks are not the same, asymmetric second and third filters are used to filter the pixels around the block boundary for smooth and dormant region modes, respectively.

[c19] 19.The method of claim 18, further comprising:
when the region mode is smooth region and the QPs of the adjacent blocks are the same, filtering the pixels around the block boundary with an N-tap symmetric second filter;
when the region mode is smooth region and the QPs of the adjacent blocks are not the same, filtering the pixels around the block boundary with an M-tap asymmetric second filter;
when the region mode is dormant region and the QPs of the adjacent blocks are the same, filtering the pixels around the block boundary with a K-tap symmetric third filter; and
when the region mode is dormant region and the QPs of the adjacent blocks are not the same, filtering the pixels around the block boundary with an L-tap asymmetric third filter.

[c20] 20.The method of claim 19, wherein:
N = 5 and the symmetric second filter is [1 3 8 3 1]/16;
M = 5 and the asymmetric second filter is [1 2 8 3 2]/16 and [2 3 8 2 1]/16;

K = 5 and the symmetric third filter is [1 2 2 2 1]/8; and L = 5 and the asymmetric third filter is [1 1 2 2 2]/8 and [2 2 2 1 1]/8.

[c21] 21.The method of claim 1, wherein filtering the pixels around the block boundary comprises first filtering the pixels at the block boundary and next filtering pixels not adjacent to the pixels at the block boundary.

[c22] 22.The method of claim 1, further comprising if the video stream comprises interlaced video, performing an interpolation operation to estimate pixel values in an interlaced field before filtering the pixels around the block boundary.

[c23] 23.The method of claim 1. wherein the video stream is an MPEG video stream.

[c24] 24.A post processing de-blocking filter comprising:
a threshold determination unit for adaptively determining a plurality of threshold values according to at least differences in quantization parameters QPs of a plurality of adjacent blocks in a received video stream and according to a user defined offset (UDO) allowing the threshold levels to be adjusted according to the UDO value;
an interpolation unit for performing an interpolation op-

eration to estimate pixel values in an interlaced field if the video stream comprises interlaced video; and
a de-blocking filtering unit for determining a filtering range specifying a maximum number of pixels to filter around a block boundary between the adjacent blocks, for determining a region mode according to local activity around the block boundary, for selecting one of a plurality of at least three filters to filter pixels around the block boundary to reduce the blocking artifact, and for filtering a plurality of pixels around the block boundary according to the filtering range, the region mode, and the selected filter;
wherein the de-blocking filtering unit further refines the filtered pixels according to the quantization parameters QPs of the adjacent blocks, or uses symmetric filters or asymmetric filters to filter the pixels according to the quantization parameters QPs of the adjacent blocks;
the de-blocking filtering unit first filters the pixels at the block boundary and next filters pixels not adjacent to the pixels at the block boundary; and
at least one of the filters is a one dimensional filter formed by using a 4-point Hadamard Transform (HT).

[c25] 25.The post processing de-blocking filter of claim 24, wherein according to the block coding types of the adjacent blocks in the video stream, the de-blocking filtering

unit determines the filtering range to be up to eight pixels around the block boundary.

[c26] 26.The post processing de-blocking filter of claim 25, wherein if at least one of the adjacent blocks is an intra-coded block, the de-blocking filtering unit determines the filtering range to be up to four pixels around the block boundary; and
if none of the adjacent blocks are intra-coded blocks, the de-blocking filter unit determines the filtering range to be up to eight pixels around the block boundary.

[c27] 27.The post processing de-blocking filter of claim 24, wherein the de-blocking filtering unit calculates an activity value representing local activity around the block boundary and determines the region mode according to the activity value.

[c28] 28.The post processing de-blocking filter of claim 27, wherein the de-blocking filtering unit calculates the activity valueas a sum of absolute differences between pixels V_I around the block boundary as follows:

$$ACTIVITY = \sum_{i=4}^{6} \left| v_i - v_{i+1} \right| + \sum_{i=8}^{10} \left| v_i - v_{i+1} \right|$$

[c29] 29.The post processing de-blocking filter of claim 28,

wherein:

if at least one of the adjacent blocks is an intra-coded block:

if the activity value is greater than a first threshold, the de-blocking filtering unit determines the region mode to be an active region;

if the activity value is less than the first threshold but greater than a second threshold, the de-blocking filtering unit determines the region mode to be a smooth region; and

if the activity value is less than the second threshold, the de-blocking filtering unit determines the region mode to be a dormant region; and

if none of the adjacent blocks are intra-coded blocks:

if the activity value is greater than a third threshold, the de-blocking filtering unit determines the region mode to be an active region;

if the activity value is less than the third threshold but greater than the second threshold, the de-blocking filtering unit determines the region mode to be a smooth region; and

if the activity value is less than the second threshold, the de-blocking filtering unit determines the region mode to be a dormant region.

[c30] 30.The post processing de-blocking filter of claim 29,

wherein the second threshold is fixed at a predetermined value.

[c31] 31.The post processing de-blocking filter of claim 30, wherein the predetermined value is 6.

[c32] 32.The post processing de-blocking filter of claim 29, wherein

if at least one of the adjacent blocks is an intra-coded block:

if the region mode is active region,

if a high frequency component (c_3) is less than a fourth threshold, the de-blocking filtering unit filters the pixels around the block boundary using a first filter;

if the region mode is smooth region,

if the absolute value of the difference of the pixel values on either side of the block boundary is less than a fifth threshold,

if the QPs of the adjacent blocks are the same, the de-blocking filtering unit filters the pixels around the block boundary using a symmetric second filter; otherwise the de-blocking filtering unit filters the pixels around the block boundary using an asymmetric second filter; and

if the region mode is dormant region,

if the absolute value of the difference of the pixel values on either side of the block boundary is less than the fifth threshold,

if the QPs of the adjacent blocks are the same, the de-blocking filtering unit filters the pixels around the block boundary using a symmetric third filter; otherwise the de-blocking filtering unit filters the pixels around the block boundary using an asymmetric third filter; and

if none of the adjacent blocks are intra-coded blocks:

if the region mode is active region,

if the high frequency component (c_3) is less than a sixth threshold, the de-blocking filtering unit filters the pixels around the block boundary using the first filter;

if the region mode is smooth region,

if the absolute value of the difference of the pixel values on either side of the block boundary is less than a seventh threshold,

if the QPs of the adjacent blocks are the same, the de-blocking filtering unit filters the pixels around the block boundary using the symmetric second filter; otherwise the de-blocking filtering unit filters the pixels around the block boundary using the asymmetric second filter; and

if the region mode is dormant region,

if the absolute value of the difference of the pixel values on either side of the block boundary is less than the seventh threshold,

if the QPs of the adjacent blocks are the same, the de-blocking filtering unit filters the pixels around the block

boundary using the symmetric third filter; otherwise the de-blocking filtering unit filters the pixels around the block boundary using the asymmetric third filter.

[c33] 33.The post processing de-blocking filter of claim 32, wherein:
the symmetric second filter is an N-tap symmetric filter;
the asymmetric second filter is an M-tap asymmetric filter;
the symmetric third filter is a K-tap symmetric filter; and
the asymmetric third filter is an L-tap asymmetric filter.

[c34] 34.The post processing de-blocking filter of claim 33, wherein:
the N-tap symmetric filter is [1 3 8 3 1]/16;
the M-tap asymmetric filter is [1 2 8 3 2]/16 and [2 3 8 2 1]/16;
the K-tap symmetric filter is [1 2 2 2 1]/8; and
the L-tap asymmetric filter is [1 1 2 2 2]/8 and [2 2 2 1 1]/8.

[c35] 35.The post processing de-blocking filter of claim 32, wherein the high frequency component (c_3) is calculated using pixels v_6, v_7, v_8, v_9 around the block boundary as follows:
$c_3 = (v_6 - v_7 + v_8 - v_9)/2$.

[c36] 36. The post processing de-blocking filter of claim 32, wherein the first filter is a one dimensional filter formed by using the 4-point Hadamard Transform (HT), wherein the high frequency coefficient of the HT is reduced to 0 for fame-coded pictures.

[c37] 37. The post processing de-blocking filter of claim 32, wherein the first filter is a one dimensional filter formed by using a 4-point Hadamard Transform (HT), wherein the high frequency coefficient of the HT is reduced to one half for field-coded pictures.

[c38] 38.The post processing de-blocking filter of claim 32, wherein the filtered pixels are further refined by adjusting a pixel quantized with a larger QP to have more change in value than a pixel quantized with a smaller QP.

[c39] 39.The post processing de-blocking filter of claim 38, wherein the de-blocking filtering unit uses a first weighting value WT1 and a second weighting value WT2 for adjusting the filtered pixels, WT1 and WT2 being obtained from a first quantization parameter QP1 of a first adjacent block and a second quantization parameter QP2 of a second adjacent block as follows:

$$WT1 = {QP1}/{QP1+QP2}, \quad WT2 = {QP2}/{QP1+QP2}$$

[c40] 40.The post processing de-blocking filter of claim 24, being capable of performing post processing de-blocking filtering on an incoming MPEG video stream.